SUBMISSION INSTRUCTIONS NO. 05

GROUNDWATER MONITORING AND SAMPLING & ANALYSIS PLANS FOR NEW SOLID WASTE DISPOSAL FACILITIES

I. APPLICABILITY OF INSTRUCTIONS

These instructions apply to applications submitted for new sanitary, industrial, or construction & demolition debris, solid waste landfills; predicated on the prior satisfactory completion of the site geotechnical study required in *Submission Instructions No. 1*. The instructions refer to requirements contained in the Virginia Solid Waste Management Regulations (VSWMR) promulgated by the Virginia Waste Management Board, effective December 18, 1988, as amended, and describe the information to be included in groundwater monitoring, and groundwater sampling and analysis plans. An example format for the plans may be found as Attachment 1 to these instructions. The information provided in the groundwater monitoring, and groundwater sampling and analysis plans shall become part of Module X of the facility's Permit.

II. GROUNDWATER MONITORING PROGRAM

[§§ 250.D.2, 260.B.11, 260.C.12, 260.D.2, 270.B.12, 270.C.8, 270.D.2, 520.A., 520.B., 9 VAC 20-80-10]

The facility's groundwater monitoring program (GMP) shall be capable of determining the impact to groundwater quality of the uppermost aquifer during the active life and post-closure care period. The technical information submitted may also be made a part of the design plans and report or the facility's operation manual, but must also be submitted as separate documents which can be incorporated into permit Module X. At a minimum, the GMP shall address all the technical information specified in these instructions, and shall include a Site Plan drawing which identifies all physical aspects of the groundwater monitoring network. The GMP shall be written and certified by a qualified groundwater scientist and shall contain a discussion of site geology and the characteristics of the uppermost aquifer. The groundwater sampling and analysis plan (GSAP) shall describe site procedures for sample collection, preservation, shipment, analysis, chain-of-custody, QA/QC, the statistical evaluation of the laboratory analytical results, and reporting procedures.

A. Site Location Information

Provide a copy of the portion of a USGS 7 ½ minute topographic map showing the location of the facility as a Figure in the GMP. Describe the location, noting the county and municipality in which the landfill will be located and the main access route to and from the facility.

B. Description of the Uppermost Aquifer

[§ 510.E.2, § 510.E.5, and 9 VAC 20-80-10]

At a minimum, the GMP shall identify:

- The geologic and hydrogeologic setting (include copies of any published geologic maps which cover the site area as a Figure in the GMP).
- The site soils as described in published USDA Soil Conservation Service surveys and as identified from on site borings.
- The uppermost aquifer, as defined through on-site subsurface investigations.

- Any hydraulically interconnected underlying aquifers (i.e., all likely subsurface flow-paths for waste constituents that may leak from the facility).
- Any topographic or geomorphic features that may influence the groundwater flow system.
- An interpretation of the vertical and horizontal components of groundwater flow.
- A description of the field methods used in the study.
- The supporting data (published information) used to produce the GMP appropriately cited and keyed to the reference section of the GMP.

In addition, include the following site-specific hydrologic data as Appendices to the GMP:

- A classification and description of the properties (hydraulic conductivity, porosity, texture, thickness, etc.) of all site hydrogeologic units (i.e., aquifers and any intervening saturated and unsaturated units).
- Geologic cross sections showing the extent of on-site hydrologic units contained in the uppermost aquifer, and any intervening aquitards.
- Groundwater elevation data from: (a) groundwater water table contour maps and (b) well or piezometer hydrographs.
- A summary of the groundwater monitoring information available to date.
- Include historical groundwater surface elevation measurements in a Table format.

C. Groundwater Monitoring Program Plan Sheet

1. Monitoring Wells.

[§§ 520.A.1.g. and 520.A.1.j.(13), 9 VAC 20-80-10]
The GMP plan sheet must show the location of all groundwater monitoring devices planned for installation on site, the boundaries of the waste management unit(s), phasing of cells, the facility boundary, and any surface water features including seeps and springs.

2. Table of Sampling Parameters.

[§ 520.A.1.g., 9 VAC 20-80-10]
The GMP plan sheet must include a table indicating the groundwater constituents to be monitored for [i.e. Appendix 5.5 list] before site development, and during the active life and post-closure care period.

3. Table of Sampling Frequency.

[§ 520.A.1.g., 9 VAC 20-80-10]
The GMP plan sheet must include a table indicating the frequency (i.e. quarterly, semi-annual) of groundwater monitoring prior to site development, during active life, and during post-closure care.

4. Cross Sections.

[§ 520.A.1.h., 9 VAC 20-80-10]
The GMP plan sheet shall show a series of site cross section lines, drawn perpendicular and parallel to the site base line at a maximum separation distance of 500 feet, and at points of grade break and important construction features. The individual cross-section drawings shall be included as an Appendix to the GMP, or may be included as separate sheets to the plan sheet.

D. Design of the Groundwater Monitoring system

[§§ 250.D.3., 260.D.3., 270.D.3., 520.A.1g, 520.A.1h, 520.A.1i, and 520.B.3a, 9 VAC 20-80-10]

The groundwater monitoring system described in the GMP must be capable of yielding groundwater samples representative of the uppermost aquifer. The design of the system shall address the requirements shown below.

1. General.

[§ 250.D.3a, 260.D.3.a., 270.D.3.a, 9 VAC 20-80-10]

The GMP shall describe how the geotechnical report submitted with the Part-A Application supports the number of proposed upgradient and downgradient monitoring points. Table 1 of these submission instructions identifies some common factors that may determine the total number of site monitoring wells to be installed.

2. Downgradient Wells.

[§ 250.D.3a(2), 260.D.3.a(2), 270.D.3.a(2), 9 VAC 20-80-10]

Describe how the proposed downgradient groundwater monitoring wells will be located to detect releases from the waste management unit(s) in the shortest period of time. A minimum of three downgradient monitoring wells is required.

a. Horizontal Placement.

Describe how the selected horizontal placement of the monitoring wells will intercept any potential pathways for contaminant migration (i.e. zones with relatively high intrinsic hydraulic conductivity, fractured or faulted zones, solution channels, or other heterogeneous formations). State the maximum lateral horizontal distance between each downgradient monitoring well.

b. Vertical Placement of Well Screen.

Describe how the well screen intervals and lengths will be selected to provide immediate detection of a release to the uppermost aquifer. Illustrate that the upgradient and downgradient well screens intercept the same uppermost aquifer.

When a single well cannot adequately intercept and monitor the vertical extent of a potential pathway of contaminant migration, a well cluster shall be used. Factors shown in Table 2 of these submission instructions may influence the number of wells needed at a location.

3. Upgradient Wells.

[§ 250.D.3a(1), 250.D.3f(2), 260.D.3a(1), 270.D.3a(1), 9 VAC 20-80-10]

Describe how the proposed upgradient (background) well(s) will be located to provide representative samples of groundwater in the same portion of the aquifer monitored by the downgradient wells. At least one upgradient well point is required. At a minimum, the GMP shall provide answers for the following:

- Are the upgradient wells far enough away from the waste management unit boundary to prevent any effects from contamination related to the disposal areas such as mounding?

- Are enough upgradient wells installed and screened at proper depths to adequately account for possible spatial variability of the aquifer?

4. Special Conditions.
[§ 250.D.4e, 260.D.4e, 270.D.4e, 9 VAC 20-80-10]
At a minimum, the GMP shall describe whether any of the special conditions listed below exist on site. If present, the GMP must note how the groundwater monitoring system will be designed to take into account these special conditions. If none of the conditions below exist at the site, the GMP must state this explicitly.

- Waste management units located above a mounded groundwater table.
- Waste management units located above aquifers with seasonally variable groundwater flow directions.
- Waste management units located close to an upgradient property boundary limiting access to install upgradient monitoring points.
- Waste management units located in areas where nearby surface water features or proximity to tidally influenced surface water bodies may influence groundwater levels or expected flow paths.
- Waste management units located near intermittently or continuously used groundwater production wells.
- Waste management units located in Karst (carbonate bedrock) or faulted areas where subsurface geologic features may modify expected groundwater flow paths.

5. Non-Upgradient Background Wells.
[§ 250.D.4e, 260.D.4e, 270.D.4e 9 VAC 20-80-10]
For wells that are not located upgradient from the disposal unit, but are proposed for use as background monitoring points, the GMP must demonstrate that either:

- the hydrogeologic conditions do not allow an exact determination of upgradient well points;
- or that sampling other wells will provide background groundwater quality that is as representative or more representative than that from a hydrologically upgradient well; or
- that there is insufficient upgradient area within which to install monitoring wells as a result of the facility boundary situations.

6. Monitoring Well Replacement.
[§ 250.D.3e]
The GMP shall indicate that any site monitoring well which fails to perform as designed, due to either:

- internal damage,
- external damage,
- a change in the elevation of the groundwater table, or
- development of phased waste cells,

shall be replaced prior to the next regularly scheduled groundwater sampling event to ensure the entire groundwater monitoring system continues to meet requirements of the VSWMR.

E. Geotechnical Investigation Techniques

1. Drilling Methods.

[§ 250.D.3d, 260.D.3b, 270.D.3b, 9 VAC 20-80-10]
The GMP shall indicate the drilling method used. Selection of the drilling method should be based on minimizing disturbance of subsurface materials and limiting the risk of cross-contamination of groundwater.

2. Equipment Decontamination.

The GMP shall describe the equipment decontamination procedures used during monitoring well installation.

3. Description of Drilling Fluids.

If drilling fluid(s) are used on site, list steps to be taken to prevent cross-contamination of the surficial aquifer. Identify drilling fluid(s) used and provide laboratory analyses to ensure they are contaminant free.

4. Soil and Rock Sampling Techniques.

Identify how soil samples and rock cores will be obtained on site. Describe the field or laboratory analysis to be conducted on the collected samples.

F. Monitoring Well Construction

1. Construction Materials.

[§ 250.D.3c, 260.D.3b, 270.D.3b, 9 VAC 20-80-10]
List well construction materials and identify how the chosen materials will allow the wells to last throughout the active life and post-closure care period of the facility but will not affect the ability to obtain representative samples of groundwater.

a. Casing and Screen Type.

[§ 250.D.3c, 260.D.3b, 270.D.3b, 9 VAC 20-80-10]
Describe how the well design will ensure that:

- The intake will allow sufficient groundwater flow for sampling,
- Will minimize the entry of formation materials into the well casing, and
- Will ensure sufficient structural integrity to prevent the collapse of the intake structure.

For wells completed in unconsolidated materials, the intake of a well should consist of a screen or slotted casing with openings sized to ensure that formational material is prevented from passing into the well during development. Screens shall not be field-slotted.

The GMP shall describe the construction materials chosen for the well casings and screened intervals. In making a selection, the designer must consider the following situations:

- Long term structural integrity (ability of the well to operate over the active life and post-closure care period of the facility).
- Well construction materials should be inert (not bias the collection and analysis of low concentrations of inorganic or organic constituents by reacting with groundwater samples).
- Well casings and screens must be structurally sound to withstand vigorous well development procedures.

b. Filter Pack.
Describe the materials used to construct the filter pack and show that the materials are chemically inert, well rounded, dimensionally stable and of proper size in relation to the screen slot size and the natural aquifer matrix.

c. Grouting Procedure.
Show that the materials used to seal the annular space will prevent the migration of contaminants to the sampling zones and prevent cross contamination between strata. They should be chemically compatible with the potential leachate to ensure seal integrity.

d. Surface Completion and Protective Measures.
Describe surface completion and protective measures used to prevent surface run-off from entering and infiltrating down the annulus of the well and to protect the well from accidental damage or vandalism.

2. Well Survey Methods.
Describe the methods to be used during the horizontal and vertical surveying of monitoring wells. Wells must be surveyed with an accuracy of 0.01 feet (vertically) and 0.05 feet (horizontally) and a reference point must be established somewhere on the well casing. The GMP shall note whether the surveying will be conducted by a licensed, or otherwise certified, land surveyor.

G. Well Development
Describe the field methods used to restore natural hydraulic conductivity after well construction is complete. The method(s) used for well development should involve reversals or surges in flow to avoid particle bridging. Post- development groundwater samples must be clay- and silt-free.

H. Well Abandonment
[§ 510.E.1j, 9 VAC 20-80-10]
The GMP shall include an abandonment plan which describes the methodology for proper abandonment of test pits, temporary borings, and monitoring wells which are removed from service due to damage, change in groundwater elevations, or phased waste cell development.

I. Documentation
[§ 250.D.3d, 260.D.3c, 270.D.3c, 9 VAC 20-80-10]
The GMP should, at a minimum, document the field information listed in Table 3 of these submission instructions.

J. Certification

[§ 250.D.3f(3), 9 VAC 20-80-10]

The GMP must indicate that a letter, certified by a qualified groundwater scientist, will be submitted to the Director within 14 days of well completion acknowledging that the monitoring well(s) have been installed in accordance with the submitted plans, and/or applicable RCRA standards.

III. GROUNDWATER SAMPLING AND ANALYSIS PLAN

[§ 250.D.4., 260.D.4, 270.D.4, 9 VAC 20-80-10]

Applicants for new solid waste disposal facility permits are expected to develop a groundwater sampling and analysis plan (GSAP). The GSAP shall describe procedures and techniques for sample collection, preservation and shipment, analytical procedures, and chain-of-custody and quality control. The GSAP shall also describe the procedures that will be used to evaluate the analytical results of the groundwater sampling during the monitoring program, and provide information on the actions to be taken if it is determined that landfill constituents may have entered the groundwater in statistically significant concentrations.

A. Sample Collection

[§ 250.D.4a(1), 260.D.4a(1), 270.D.4a(1), 9 VAC 20-80-10]

The GSAP shall describe sample collection procedures that are designed to ensure monitoring results that provide an accurate representation of groundwater quality.

1. Static Water Level Elevations.

[§§ 250.D.4c, and 260.D.4b, 260.D.5d, 270.D.4c, 270.D.4d, 270.D.5d, 9 VAC 20-80-10]

The GSAP shall describe the process of obtaining static water elevations on site. The GSAP shall note that groundwater elevations will be measured in each well during each groundwater sampling event. The measurements taken shall include depth to water, and total well depth (0.01' accuracy).

2. Well Evacuation.

The GSAP should describe the step-by-step method used to remove the standing water in the well and filter pack prior to groundwater sampling. The choice of the purge method will depend on the aquifer's hydraulic yield characteristics. The GSAP shall describe the calculations used to determine well volume removed, equipment used in the purge process, the method of purge water storage and disposition, and a description of decontamination procedures to be followed.

3. Number of Samples.

[§§ 250.D.4f and 250.D.5c(2), 9 VAC 20-80-10]

The GSAP shall indicate the number, quantity, and the type of groundwater samples collected for groundwater monitoring constituents during each sampling event. If the facility intends to show that the frequency of the sampling should be less than specified in the Regulations, the illustration must be included in a separate document submitted to the Director, noting the following information:

- Lithology of the aquifer and unsaturated zone;

- Hydraulic conductivity of the aquifer and unsaturated zone;
- Groundwater flow rates:
- Minimum distance between upgradient edge of the disposal unit and downgradient monitoring well screen; and
- Resource value of the aquifer.

4. Sampling Equipment.
The GSAP shall specify the equipment used to minimize sample agitation and reduce contact with atmosphere during sample transfer. When used properly, the following devices are acceptable:

- Gas-operated, fluorocarbon resin or stainless steel squeeze pump ("bladder pump") with adjustable flow control;
- Bailer (fluorocarbon resin or stainless steel), provided it is equipped with double check valves and bottom emptying device; and
- Syringe bailer (fluorocarbon resin or stainless steel).

5. Sampling Order.
The GSAP shall specify how to determine the order in which the monitoring wells will be sampled on site, taking into account

- Prior levels of impact to groundwater and
- The order of volatilization of the groundwater sampling parameters.

6. Sampling Measurements
Temperature, pH, and specific conductance measurements should be made in the field before and after sample collection as a check on stability of the groundwater during the sample period. Turbidity at each well, measured in NTU's, should be noted during the groundwater sampling procedure.

7. Decontamination & Calibration Procedures.
If dedicated equipment will not be used during groundwater sampling, the GSAP shall describe the methods that will be used in disassembly and decontamination between sampling events at individual wells. The GSAP should also describe the calibration methods used on any direct-read monitoring/sampling equipment.

B. Sample Preservation and Handling
[§ 250.D.4a(2), 260.D.4a(2), 270.D.4a(2), 9 VAC 20-80-10].
The GSAP shall address the sample preservation methods and the container types used on site.

1. Sample Containers.
The GSAP shall describe the sample container type and procedures used to ensure that containers are free of contaminants prior to use. Acceptable containers are shown in *Test Methods for Evaluating solid Wastes – Physical/Chemical Methods (SW-846 – USEPA)*.

2. Sample Preservation.
The GSAP shall list sample preservation methods that will be used to retard or reduce biological action, hydrolysis, and sorption effects.

C. Chain-of-Custody
[§ 250.D.4a(4), 260.D.4a(4), 270.D.4a(4), 9 VAC 20-80-10]
The GSAP shall describe the chain-of-custody program that will allow for the tracking of possession and handling of individual samples from the time of field collection through laboratory analysis. The chain-of-custody program shall include the following elements.

1. Sample Labels.
Sample labels affixed to the samples shall contain at least the following information:

- Sample identification number;
- Name of collector;
- Date and time of collection;
- Place of collection;
- Parameters to be analyzed for (if space permits);
- Internal temperature of shipping container at time sample was placed;
- Internal temperature of shipping container upon opening at laboratory; and
- Maximum and minimum temperature range that occurred during shipment.

2. Sample Seal.
When samples will leave the operator's immediate control, such as shipment to a laboratory by a common carrier, a seal shall be placed on the shipping container or individual sample bottles to ensure that the samples have not been disturbed during transportation.

3. Field Logbook.
The GSAP shall at a minimum, record the information included in Table 4 of these submission instructions within a field notebook. The information shall be recorded by the individual(s) collecting the groundwater samples.

4. Chain-of-Custody Record.
To establish the documentation necessary to track sample possession from time of collection, a chain-of-custody record should be filled out and should accompany every sample. The record should contain the following types of information:

- Sample number;
- Signature of collector;
- Date and time of collection;
- Sample type;
- Identification of well;
- Number of containers;
- Parameters requested for analysis;
- Signature of person involved in the chain of possession;
- Inclusive dates of possession;
- Internal temperature of shipping container when samples were placed into it;
- Maximum temperature recorded during shipment;
- Minimum temperature recorded during shipment; and

- Internal temperature of shipping container upon opening in the laboratory.

D. Laboratory Analytical Procedures.
[§§ 250.D.4a(3), 260.D.4b, 270.D.4a(3), 270.D.4b, 9 VAC 20-80-10]
The GSAP shall note the analytical procedures to be used on the groundwater samples (selected from among those contained in *Test Methods for Evaluating Solid Waste – Physical/Chemical Methods, SW-846 – USEPA*). The GSAP shall identify one analytical method for each specific groundwater parameter on the Appendix 5.5 list (Detection monitoring). Proper quality assurance and control protocols, method detection limits (MDLs), laboratory limits of detection (LODs), laboratory limits of quantitation (LOQs), and percent recovery specifications should be clearly identified in the GSAP. The method chosen must meet USEPA performance standards under *Test Methods for Evaluating Solid Waste – Physical/Chemical Methods, SW-846 – USEPA.*

E. Quality Assurance and Quality Control (QA/QC)
[§§ 250.D.4a(5), 250.D.4b, 260.D.4a, 260.D.4b, 270.D.4a, 270.D.4b, 9 VAC 20-80-10]
The GSAP shall explicitly describe the QA/QC program to be used in the field and laboratory. If commercial laboratories are used, the operator must ensure that the laboratory of choice is exercising a QA/QC program that meets or exceeds *Test Methods for Evaluating Solid Waste – Physical/Chemical Methods, SW-846 – USEPA.*

1. Field QA/QC Program.
The GSAP shall provide for the routine collection and analysis of trip and equipment blanks to verify that the sample collection and handling process has not affected the quality of the samples. The GSAP shall also describe a program for ensuring proper calibration of field equipment (prior to field use and re-calibrated in the field before measuring each sample) and equipment decontamination and chain-of-custody procedures.

2. Laboratory QA/QC Program.
The GSAP shall describe the use of standards, laboratory blanks, duplicates, and spiked samples for calibration and identification of potential matrix interference problems.

F. Establishing Background Data

1. Background Data from Downgradient Wells
[§ 250.D.4d and 250.D.4e, 9 VAC 20-80-10]
The GSAP shall describe the site-specific actions required to establish background quality in hydraulically upgradient or background wells for each monitoring constituent required.

2. Background Data from Upgradient Wells
[§ 250.D.4d and 250.D.4e, 9 VAC 20-80-10]
Background may be determined based on the sampling of monitoring wells that are not upgradient if the facility describes the hydrogeologic conditions that mandate this situation.

G. Techniques for the Evaluation of Groundwater Quality Data
[§§ 250D.4h, 260.D.5e, 270.D.5e, 9 VAC 20-80-10].
The GSAP shall describe the procedures the facility will follow to determine whether or not there has been a statistically significant increase over background for any groundwater monitoring constituent. The GSAP shall include the instructions on handling and evaluation of groundwater analytical data. Prior to submitting the analytical data to the Department, the facility shall compile and interpret the results of the sampling program. The facility shall ensure that any verification sampling events are completed within the compliance period, and that the interpretation of the analytical results of such events is included in the data report submitted to the Department.

1. Reporting of Low and Zero Values.
The manual shall address the methods used to report and interpret data that are measured below a limit of detection (LOD) specified by the laboratory. These values shall never be deleted from the evaluation and shall receive the appropriate statistical treatment as described in the Department's *Data Analysis Guidelines for Solid Waste Facilities Operating in Virginia (2000) – as updated*. Once chosen, the statistical treatment method shall not be changed.

2. Missing Data Values.
The GSAP shall state that if a sampling event results in missing data, a re-sampling event shall take place within the same compliance period (as close to the date of the original sampling event as possible) to minimize the effects of possible variation in groundwater chemistry and to allow additional time for a verification sample, if one is needed.

3. Outliers.
The GSAP shall state that the background dataset for each well will be screened for the existence of outliers using a method described by the USEPA or the Department. Background observations that are considered to be outliers should not be included in the statistical analysis to preserve the power of the test to detect an actual release from the facility. If an extreme value occurs during a compliance sampling event, the GSAP shall state that the facility will collect a re-sample during the same compliance period to enable the facility to distinguish between an extreme value (outlier) or an indication of a release from the facility. The GSAP shall specify under which circumstances the operator may correct values that are much different from most other values in the data set and what documentation will be provided when these types of corrections are made.

4. Statistical Tests.
[250.D.4g, 9 VAC 20-80-10]
The GSAP shall specify the statistical method(s) selected by the facility from among those listed in Appendix 5.4 of the VSWMR, to interpret the groundwater analytical results. The statistical method chosen must be shown to meet the performance standard for the applicable data set.

If a facility chooses to perform statistical comparisons using a two- or multi-way statistical test method (i.e. t-test, ANOVA, Wilcoxon rank sum, Kruskall-Wallis), the facility will need to collect a minimum of four samples per compliance period. The VSWMR states the level of significance for performing these tests for individual well comparisons will be no less than 0.01 and no less than 0.05 for multiple comparisons. Prior to applying these tests, the facility should check distributional assumptions for both background and compliance datasets and check assumptions of homogeneity of variances.

The ANOVA test assumes data are normally or log-normally distributed and variances are homogeneous across groups. The CABF and Welch's t-tests assume data are normally or log-normally distributed and variances don't differ dramatically across groups (these tests account for some differences between variances). The Wilcoxon rank sum and Kruskall-Wallis tests assume that the distributions of the two groups are similar (though undetermined).

Statistical interval methods possibly applicable are the confidence interval, prediction interval, and tolerance interval. For all interval methods, the facility should check the normality or lognormality of the background dataset and the percentage of non-detects in the background dataset. If the background dataset is normally or log-normally distributed, and there is less than 50% non-detects, then a parametric interval can be calculated. If a distribution cannot be established for the background dataset or 50% or more of the data are non-detects, the facility should apply a non-parametric statistical limit.

The Shewhart-CUSUM control chart can be applied as an intra-well statistical test method. Please note that a variance from inter-well statistical comparisons must be granted by the Department prior to applying an intra-well only monitoring program.

In the event the facility has selected any other method listed in the VSWMR, the facility will collect the appropriate number of samples and shall maintain an appropriate level of significance mentioned above. If the facility prefers to apply a statistical method that is not in listed in the VSWMR, the facility must receive approval from the Department prior to applying the test method.

5. Verification Sampling.

The GSAP shall note whether the permittee plans to use a verification sampling strategy (collection of a pre-planned number of additional samples). The verification sample must be independent from the initial sample. In the 1 of "N" approach, the facility can take as many as "N" re-samples during the same compliance period as the initial sampling. If the 1 of "N" (usually N = 1, 2 or 3) sample is below a prediction or tolerance limit, the constituent is said to have "passed" the statistical test. If the facility chooses to apply the verification sampling strategy, the GSAP shall note that the alpha value will be modified as shown in Table 5 of these submission instructions. Since verification sampling is pre-planned, the facility can adjust the upper statistical limit calculated for background to account for the fact that the verification samples will be collected. The VSWMR do not allow a facility to disregard the statistical evaluation in situation when the facility is unable to collect a verification sample, as planned. If the facility plans on taking a

verification sample, the groundwater must be sampled during the same compliance period as the initial event, and statistical tests must include the verification sample results prior to submitting the final results to the Department.

6. Records and Reports.
[§ 250.D.8., 260.D.5b, 270.D.5b, 9 VAC 20-80-10]
The GSAP shall describe the data types that will be kept, the format in which they will be recorded, and the format and submission timelines of any required reports dealing with the results of groundwater sampling.

H. Statistical Analysis of Subsequent Well Data

1. Comparison with Subsequent Well Data.
[§ 250.D.4h, §§ 250.D.5c(3) and 250.D.5c(4), 260.D.5b, 270.D.5b, and 9 VAC 20-80-10]
The GSAP shall specify actions that operator will undertake to determine whether or not a statistically significant increase over background values for each constituent has occurred.

2. Required Response Actions.
The GSAP shall describe the facility's responses under the allowed reporting time frames for any statistically significant increases noted in one or more Detection monitoring groundwater parameters.

I. Groundwater Elevation Data Interpretation
[§ 250.D.4c, 260.D.5.d, 270.d.5d, 9 VAC 20-80-10]
The facility shall determine the rate and flow direction each time groundwater is sampled. The GSAP must describe the actions required to be taken on site if one or more of the monitoring wells is determined to no longer function as designed due to a change in the groundwater flow direction. The actions must be completed prior to the next regularly scheduled groundwater sampling event to fulfill the regulatory requirements of the groundwater monitoring system.

J. Recordkeeping and Reporting
[§ 250.D.8a, 260.D.8a, 270.D.8a, 9 VAC 20-80-10]
The GSAP must describe the recordkeeping and reporting procedures including where, and for how long, facility records will be retained; and by what date an annual groundwater monitoring report shall be submitted to the Director.

IV. REFERENCES

Both the GMP and the GSAP shall contain a full listing of any published scientific research used during the development of the both documents. The formatting of the References section shall follow that utilized by the Geological Society of America (i.e., Author's Name, Publication Date, Publication Title, Publication Source, Volume, Page Number).

V. APPENDICES

Both the GMP and the GSAP shall contain Appendices that shall include information such as, but not limited too, boring logs, groundwater flow calculations, aquifer properties data sheets, field notes, which can not be easily summarized as text in the main documents. The numbering and order of the Appendices will be up to the Permittee.

TABLE 1
FACTORS INFLUENCING THE INTERVALS BETWEEN INDIVIDUAL MONITORING WELLS

Intervals between wells should be closer if:	Intervals between wells may be wider if:
Site has factors such as: • Liquid waste is managed on-site • Site is very small in size • Permeable fill material is located near the waste management unit (where preferential flow may occur) • There are buried pipes, utility trenches, etc., where point-source leak might occur	
Site has complicated geology: • Closely spaced bedrock fractures • Faults zones • Tight folds • Karst (solution channels) • Discontinuous structures	Site has simple geology: • No fracture zones • No fault zones • No folded rocks • No Karst (solution channels) • No discontinuous structures
Site has complicated hydrogeology: • Variable hydraulic conductivity • Variable lithology • Site is in or near a recharge zone • Site has steep or variable hydraulic gradient • Site is characterized by a low dispersivity potential • Site has a high seepage velocity	Site has homogeneous conditions: • Uniform hydraulic conductivity • Uniform lithology • Site has a low (flat) and constant hydraulic gradient • Site is characterized by a high dispersivity potential • Site has a low seepage velocity

TABLE 2
FACTORS AFFECTING NUMBER OF WELL POINTS PER MONITORING LOCATION

One Well Point Per Sampling Location May Be OK If There Are:	More than One Well Point Per Sampling Location Needed If:
• No "sinkers" or "floaters" (immiscible liquid phases) expected in the groundwater	• Presence of immiscible liquids found in the groundwater
• Thin flow zone relative to monitoring well screen length	• Data indicates a heterogeneous uppermost aquifer (i.e., complicated aquifer geology)
• Data indicating a homogeneous uppermost aquifer (i.e., simple aquifer geology)	• Site has multiple, interconnected aquifers
	• Site has perched water-bearing zones
	• Groundwater is contained in discrete bedrock fracture zones

TABLE 3
INFORMATION TO BE RECORDED DURING MONITORING WELL INSTALLATION

- Date/time of construction
- Drilling method and drilling fluid used
- Bore hole and well casing diameter
- Casing materials
- Screen materials and design
- Casing and screen joint type
- Screen size/length
- Filter pack material, size, and grain analysis (D10)
- Filter pack volume calculations
- Filter pack placement method
- Sealant materials (percent bentonite)
- Sealant volume (pounds per gallon of cement)
- Sealant placement method
- Surface seal design and construction
- Well development procedure
- Type of protective well cap
- "As built" well diagram including dimensions
- Well location, specified to within 0.5 foot in horizontal plane
- Well depth, specified to within 0.01 foot
- Ground surface elevation, specified to within 0.01 foot
- Surveyor's pin elevation on concrete apron, specified to within 0.01 foot
- Top of monitoring well casing elevation, specified to within 0.01 foot
- Top of protective steel casing elevation, specified to within 0.001 foot
- Drilling and lithologic logs

TABLE 4
INFORMATION TO BE RECORDED DURING GROUNDWATER SAMPLING OF EACH COMPLIANCE MONITORING WELL

- Well identification number
- Well depth
- Static water level depth and measurement technique
- Presence of immiscible layers (yes – no)
- Estimated Well yield
- Purge volume and purge pumping rate
- Exact time well purge began and ended
- Well evacuation procedure and equipment
- Field analysis data and methods
- Climatic conditions including air temperature
- Field observations on sampling event
- Well location, specified to within 0.5 foot in horizontal plane
- Name of collector
- Date and time of sample collection
- Sampling procedure
- Sampling equipment
- Types of sample containers used and sample identification numbers
- Preservative used
- Sample destination and transporter
- Internal temperature of field and shipping containers

TABLE 5

ALPHA VALUE MODIFICATIONS FOR USE IN VERIFICATION SAMPLING STRATEGIES

a) Select a default value for α = 0.01

$$\alpha = 0.01$$

b) Pass the first or one of one verification re-samples, adjust alpha

$$\alpha = (1 - .95^{\frac{1}{k}})^{\frac{1}{2}}$$

c) Pass the first or one of two verification re-samples, adjust alpha

$$\alpha = (1 - .95^{\frac{1}{k}})^{\frac{1}{3}}$$

d) Pass the first or two of two verification re-samples, adjust alpha

$$\alpha = \sqrt{1 - 0.95^{\frac{1}{k}}}\sqrt{\frac{1}{2}}$$

Where k is the number of comparisons and α is the site-wide false positive rate. Please note that alpha can not be less than 0.01 unless the facility shows that the statistical comparison has at least as much statistical power as published EPA reference power curves.

ATTACHMENT 1

Example Table of Contents

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IV – REFERENCES

V - APPENDICES